

History History

MEG in Canada

Closing Session Biomag 2006 VCR

L. Deecke Biomag 2006 Vancouver

How it all began:

the *genius loci*

and what a magnetic attraction went out from him

Hal Weinberg



Cowboy Hat and Cadillac



Hal is a
great attractor
(not a strange attractor)

and the location was **very attractive** as well

Simon Fraser University Luftbild



Campus und Blick über die Fjorde Port Moody Inlet und Indian Arm

Seasonal
Simon Fraser University





Brandywine Meadows

a
medieval
vanity
picture



the
first
MEG
had
only
one
channel

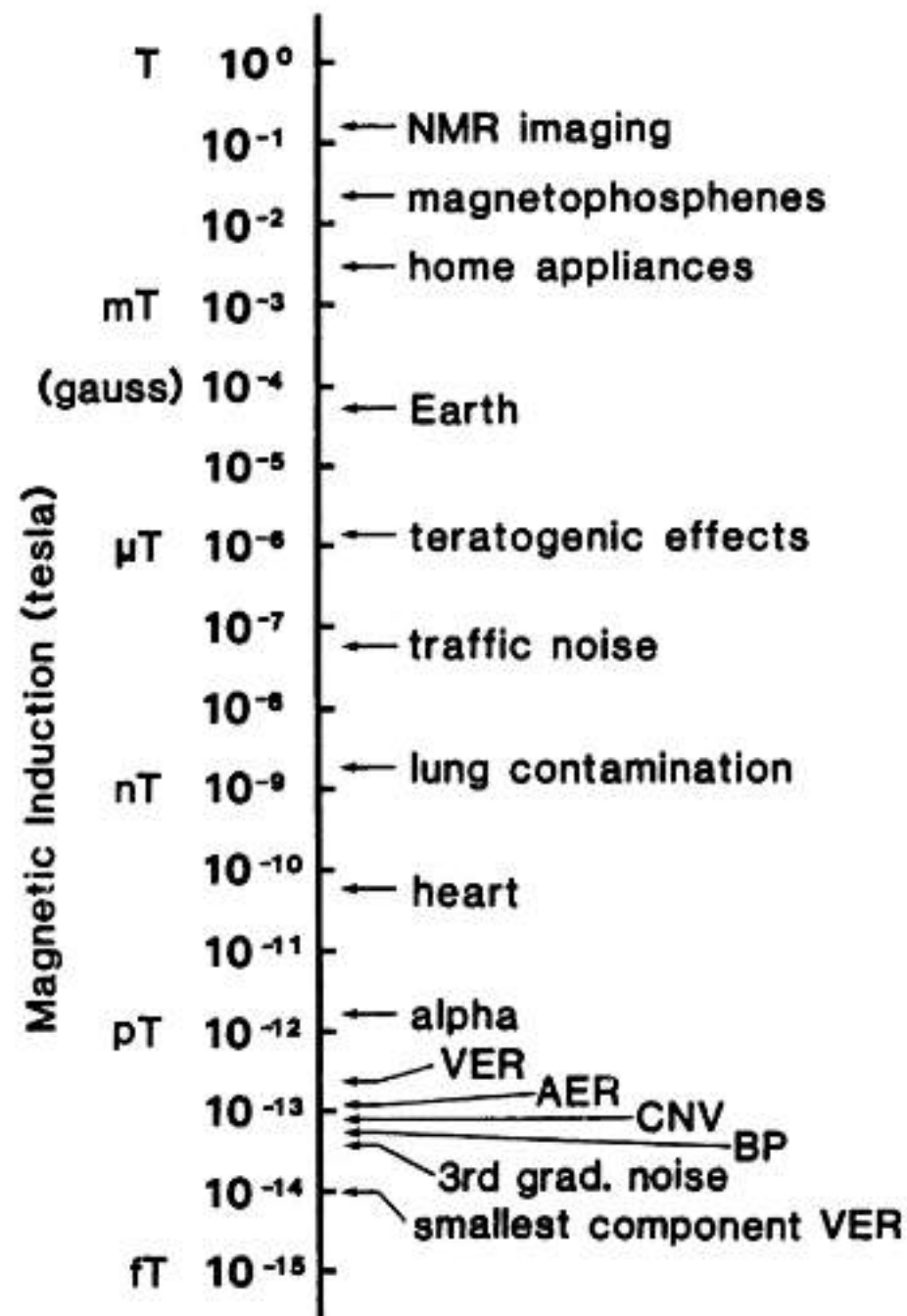


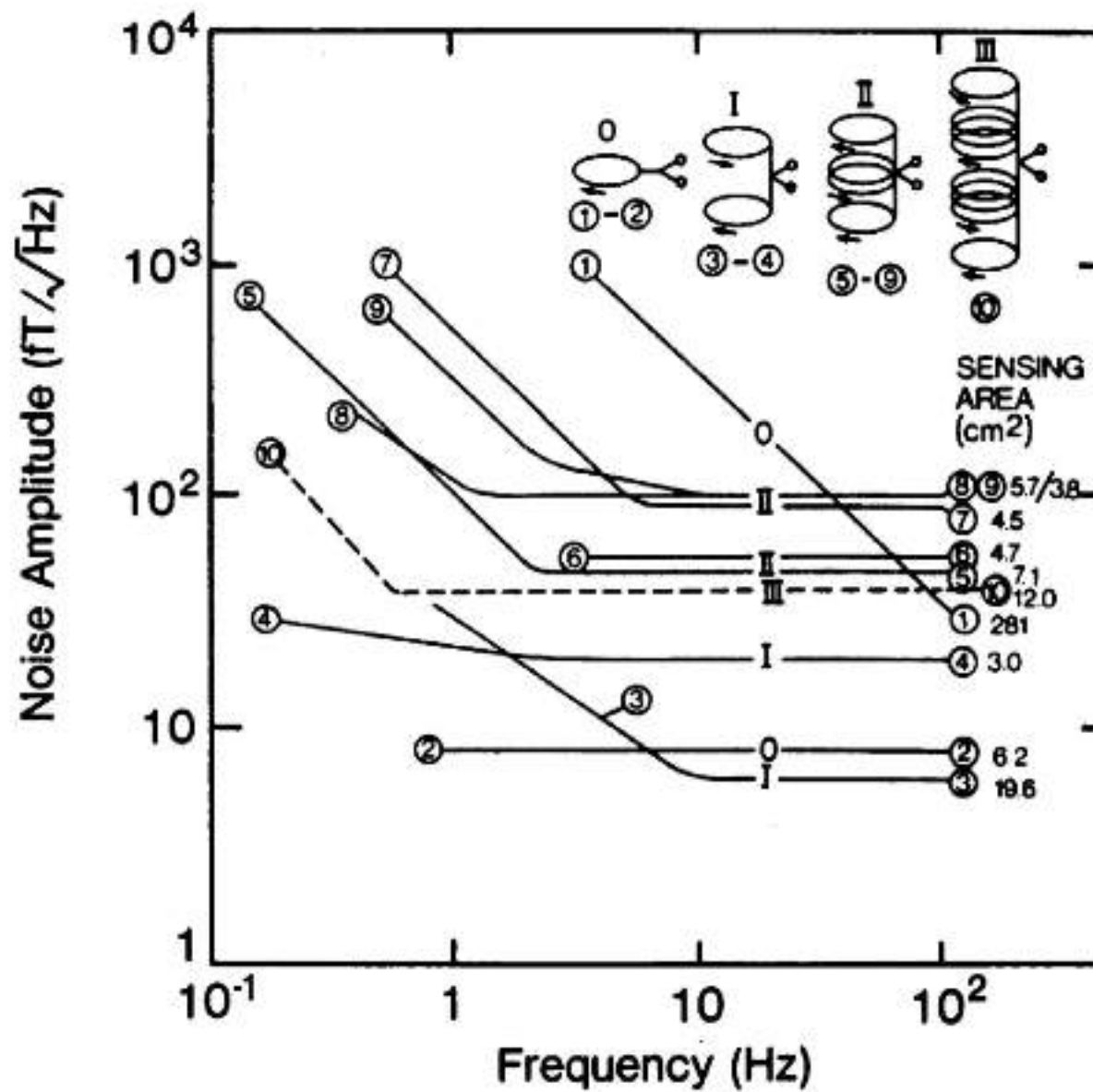
CTF

**CANADIAN
THIN
FILM**

Cars
Snowplough

MEG Range





MEG Frequency Dependency: The critical Low Frequency Range

Aus der Neurologischen Klinik und Abteilung für Neurophysiologie
der Universität Freiburg i. Br.

Hirnpotentialänderungen bei Willkürbewegungen und passiven Bewegungen des Menschen: Bereitschaftspotential und reafferente Potentiale*

Von

HANS H. KORNHUBER und LÜDER DEECKE**

Mit 7 Textabbildungen

(Eingegangen am 23. Dezember 1964)

Summary. A method of *chronological data storage and reverse computation* is described by which bio-electrical phenomena preceding "spontaneous" events within the nervous system can be analysed if these events appear repeatedly and are capable of triggering a computer.

Slow brain potentials accompanying voluntary and passive movements of the limbs were analysed by this method. These potentials were recorded from different points of the scalp from 12 healthy subjects in 94 experiments with more than 100 movements in each record. At times artifacts were superimposed upon cerebral potentials. The former were identified, and, as far as was possible, eliminated.

Voluntary hand or foot movements are *preceded* by a slowly increasing *surface-negative cortical potential* of 10–15 μ V, called *readiness potential*. This potential is maximal over the contralateral precentral region, but shows bilateral spread and is larger over the frontal than over the occipital areas. The readiness potential increases with intentional engagement and is reduced by mental indifference of the subject.

Voluntary movements are *followed* by a complex potential with an early positive phase that begins 30–90 msec after the onset of movement. The late potentials following voluntary movements are similar to those after passive movements. Both resemble the late bilateral components of the evoked potentials after electrical stimulation of peripheral nerves. Some variable differences between the early components of the potentials after the onset of active and passive movements require further investigation.

No relation between the onset of voluntary movements and the phase of the alpha rhythm could be detected.

Zusammenfassung. Eine Methode zur *chronologischen Datenspeicherung und Rückwärtsanalyse* hirnelektrischer Begleitvorgänge wiederholter Willkürbewegungen beim Menschen wird beschrieben.

Mit dieser Methode wurden langsame Hirnpotentiale 1. bei *Willkürbewegungen* von Hand und Fuß und 2. bei ähnlichen *passiven Handbewegungen* bei 12 gesunden Menschen in 94 Versuchen mit je über 100 Bewegungen in 3 Kanälen untersucht.

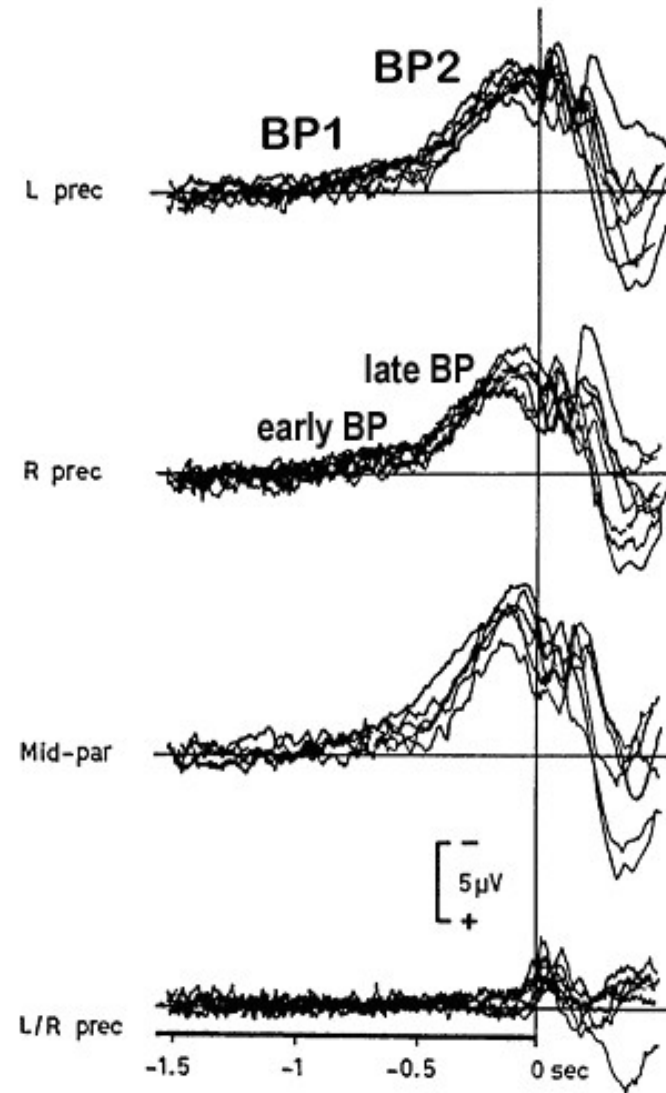
* Mit Unterstützung der Deutschen Forschungsgemeinschaft.

** Wesentliche Teile dieser Arbeit sollen von Herrn DEECKE als Dissertation der Medizinischen Fakultät der Universität Freiburg i. Br. vorgelegt werden.

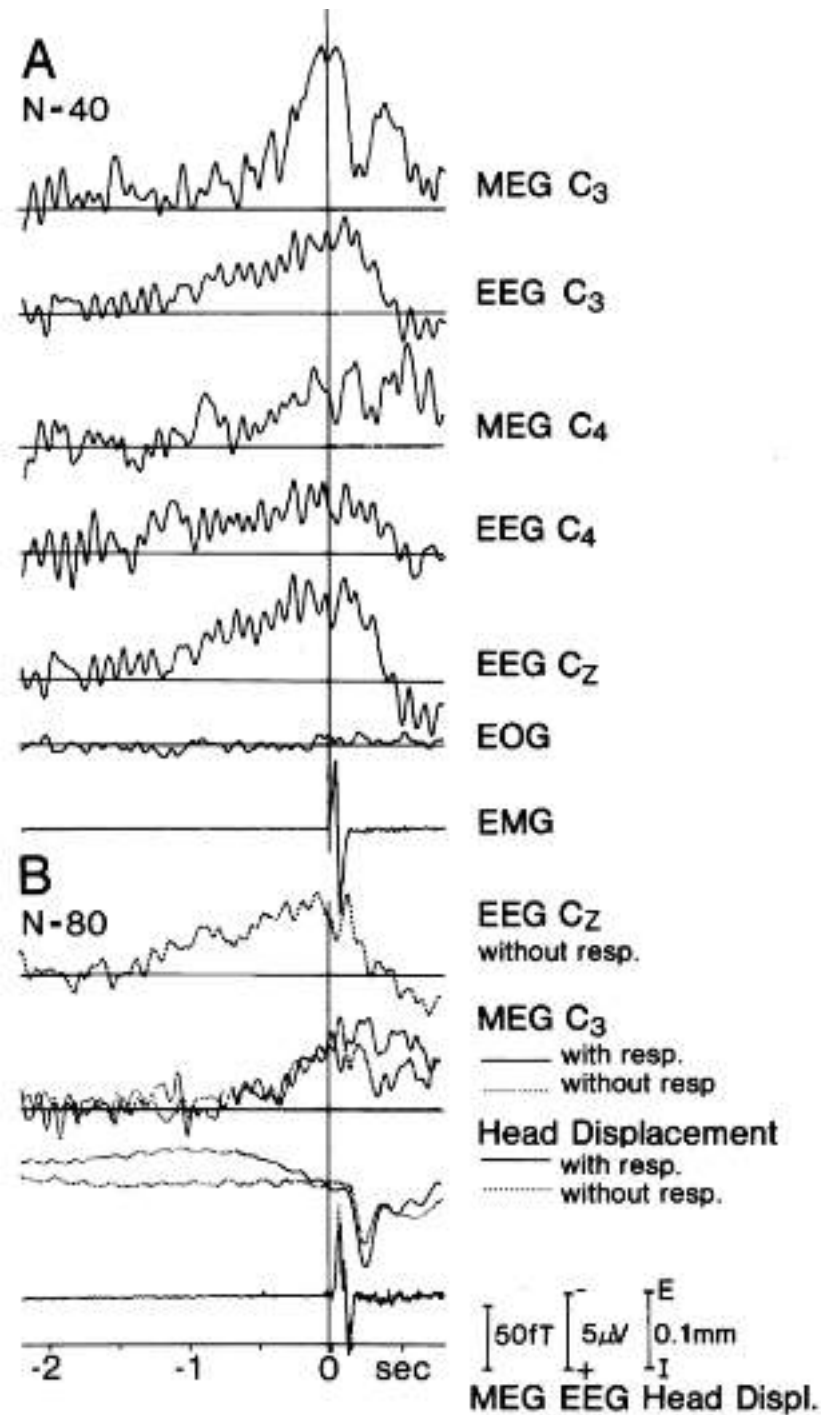
What is the Bereit- schafts- potential (BP)?

What is the Bereit- schafts- potential?

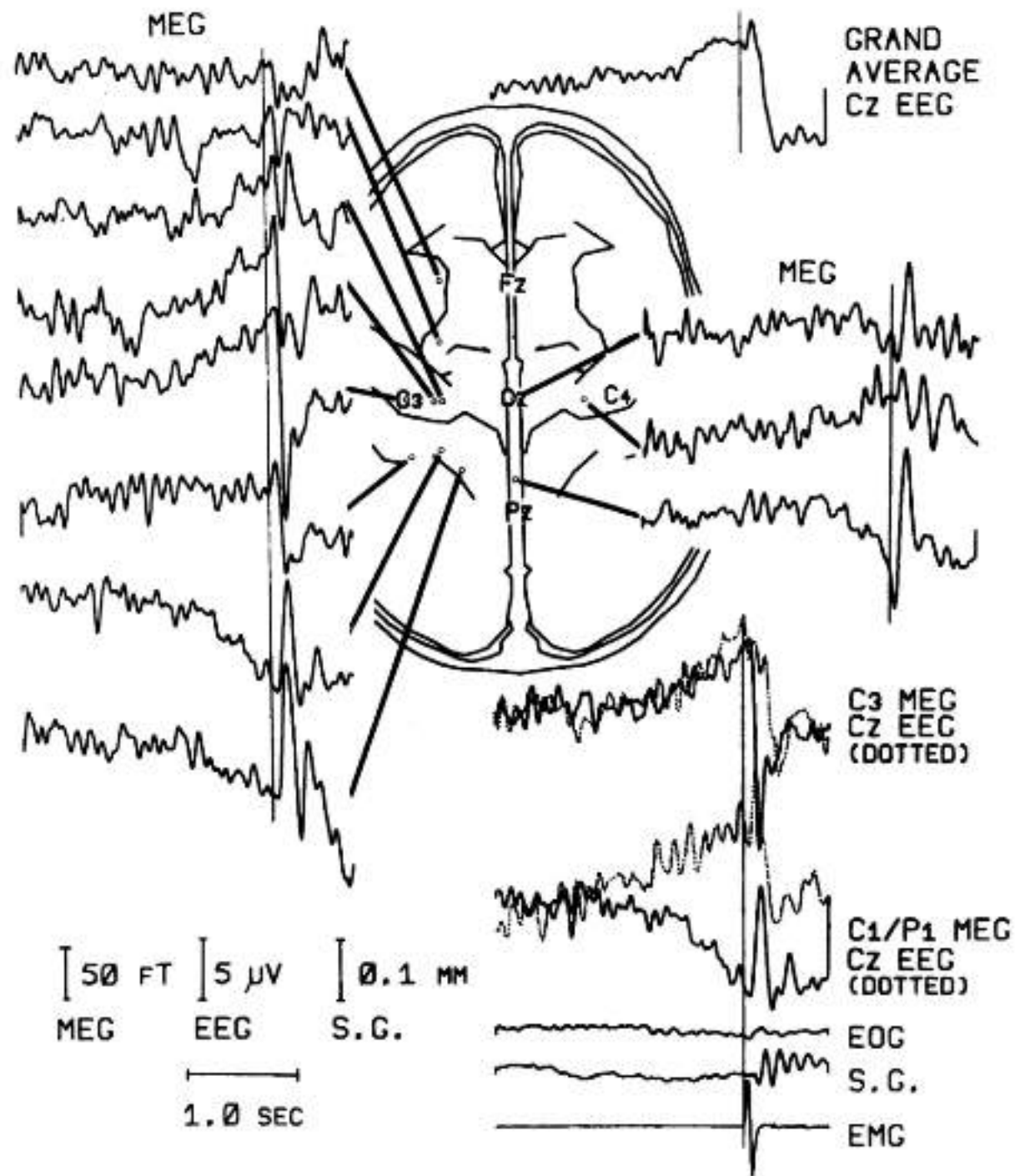
Here it is!



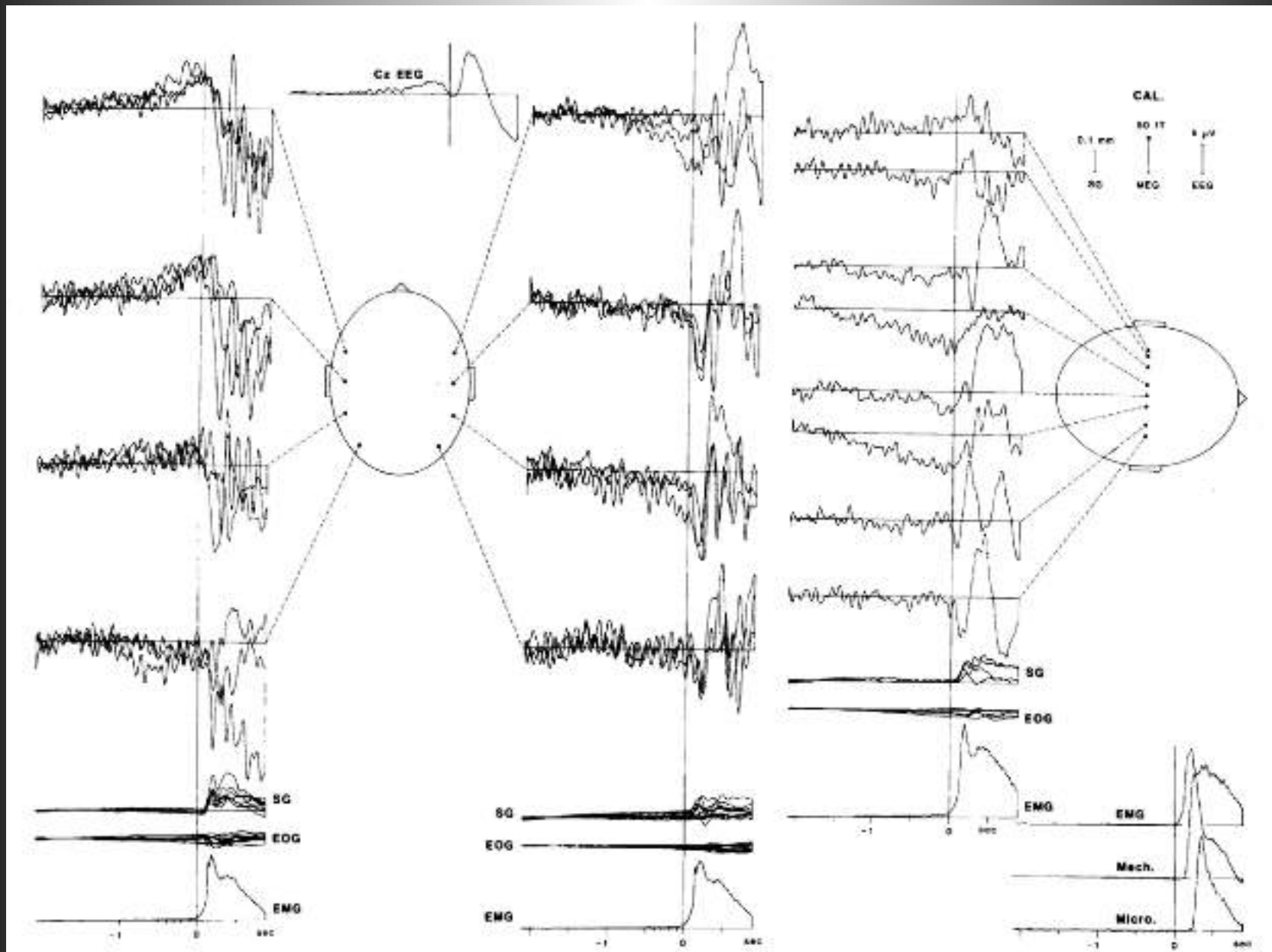
MEG First Recordings Vancouver



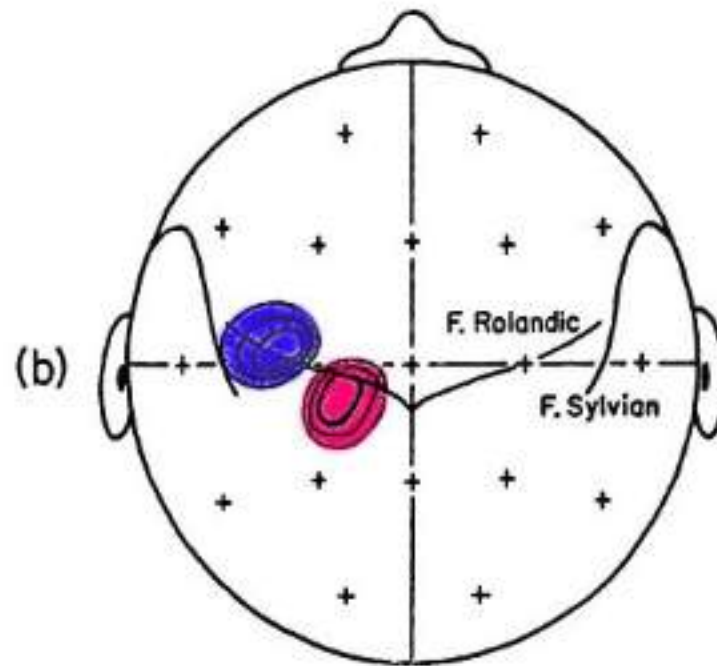
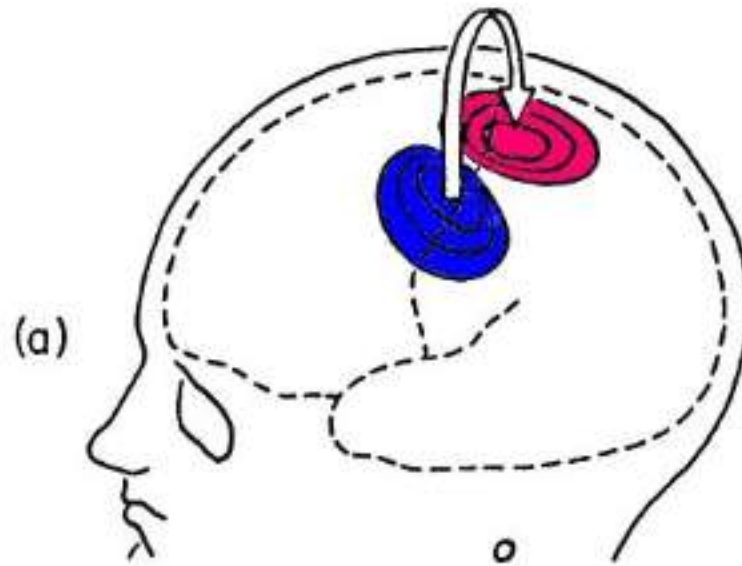
measured
with
strain
gauges



Bereitschafts
Field
Prerolandic
Retro Rolandic



MEG, Speech

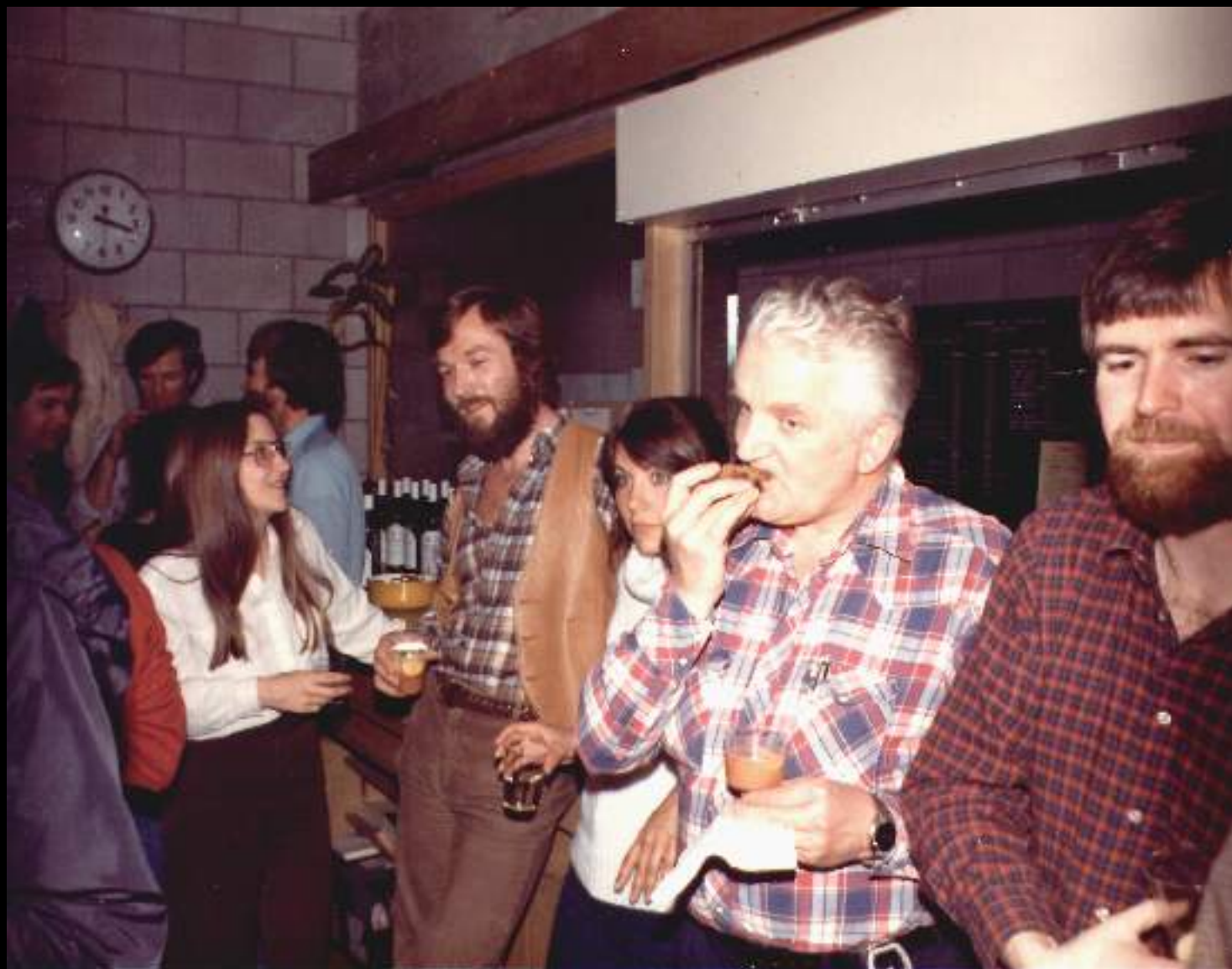


MEG
Feld
Linien
Rot rein
Blau hinaus

MEG
Field
Lines
Blue = Out
Mnemonic:
‘Out of the Blue’
Red = In



Gruppenbild mit Jansen.



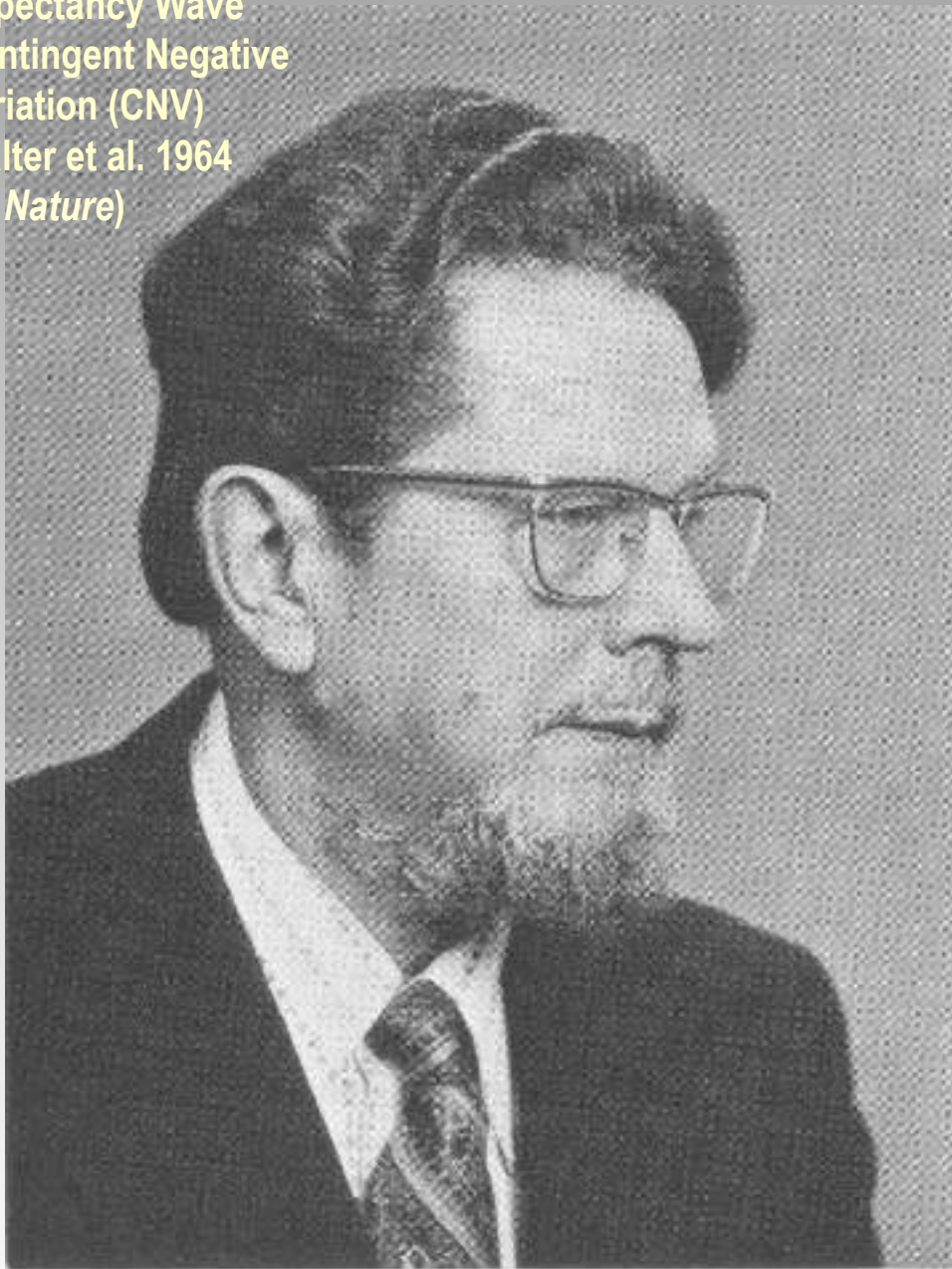


Bristol Weinberg's House (Schwitzer Bant)



Mt. Baker 5 m Schnee

Expectancy Wave
Contingent Negative
Variation (CNV)
Walter et al. 1964
(in *Nature*)



W. Grey Walter



Talking on a Party at Hal Weinberg's





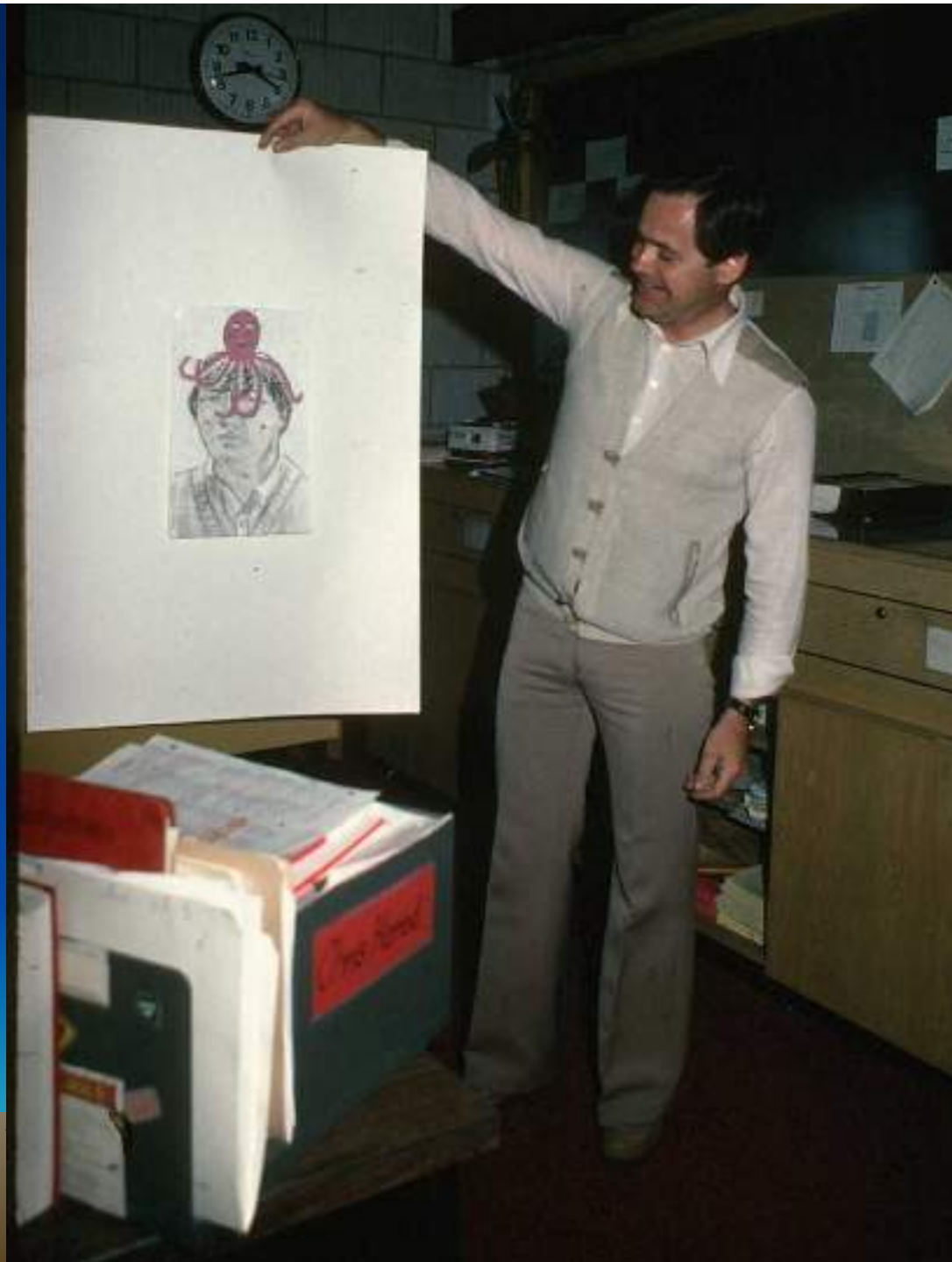
TMS

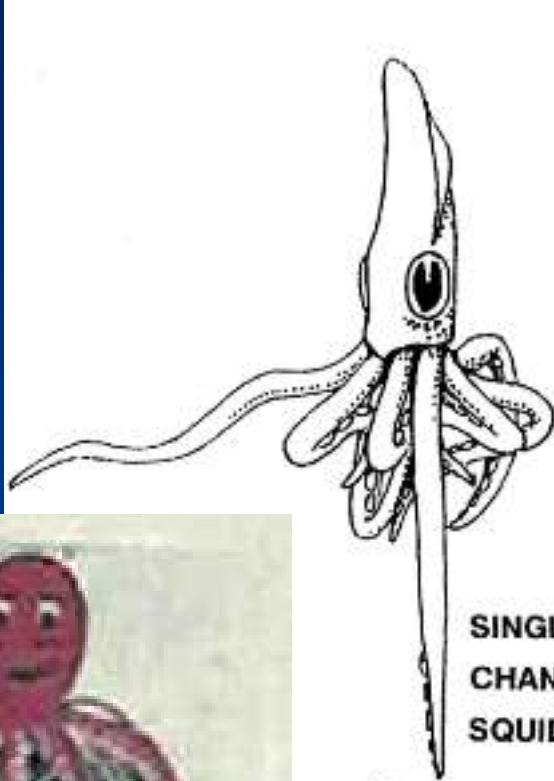




L.D.
in
Vancouver
1982
having
a
Vision:

The
Whole
Scalp
MEG

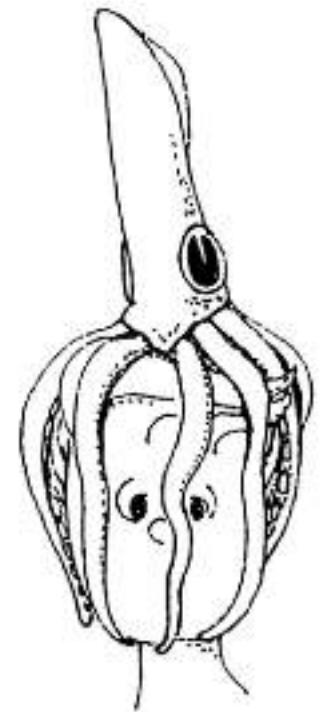




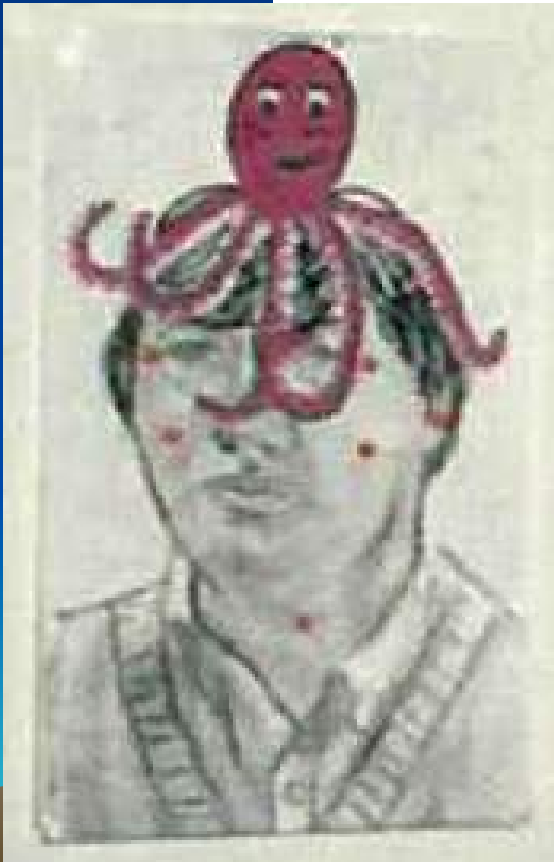
SINGLE
CHANNEL
SQUID



EIGHT
CHANNEL
SQUID



WHOLE HEAD
SQUID



The Cartoonist's View at SQUIDS



You can put other things on your head



Supranatural BC

in 1994, the vision became reality

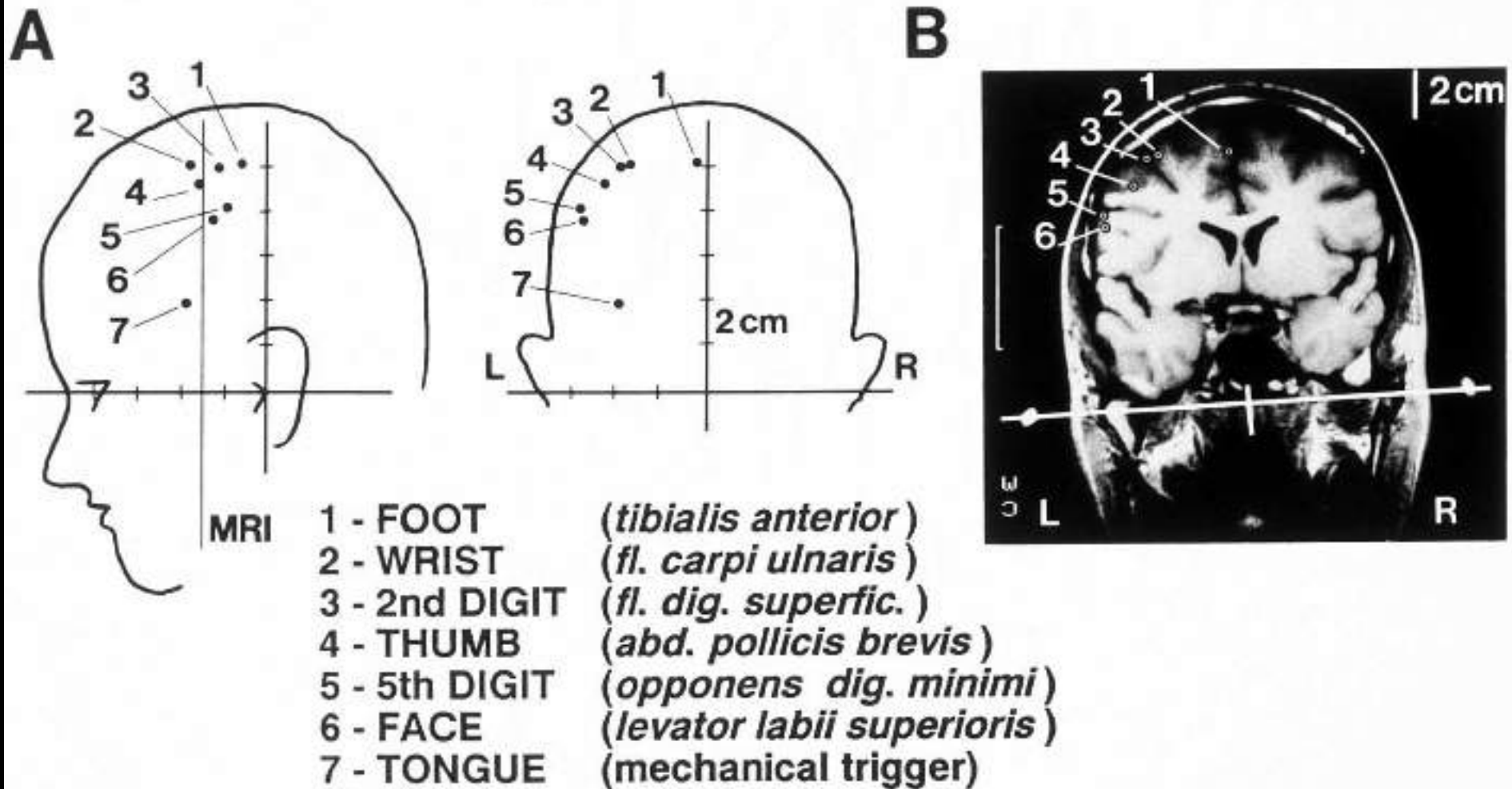


in 1994, the vision was reality



Ann Doug Bill Gaetz Hal





**The Bereitschaftspotential Homunculus is Physiological
in Contrast to Stimulation Mapping in Epileptic Patients**

353

Exp Brain Res (1991) 87:688–695

Experimental
Brain Research
© Springer-Verlag 1991

Three-dimensional localization of SMA activity preceding voluntary movement

A study of electric and magnetic fields in a patient with infarction
of the right supplementary motor area

W. Lang, D. Cheyne, R. Kristeva, R. Beisteiner, G. Lindinger, and L. Deecke

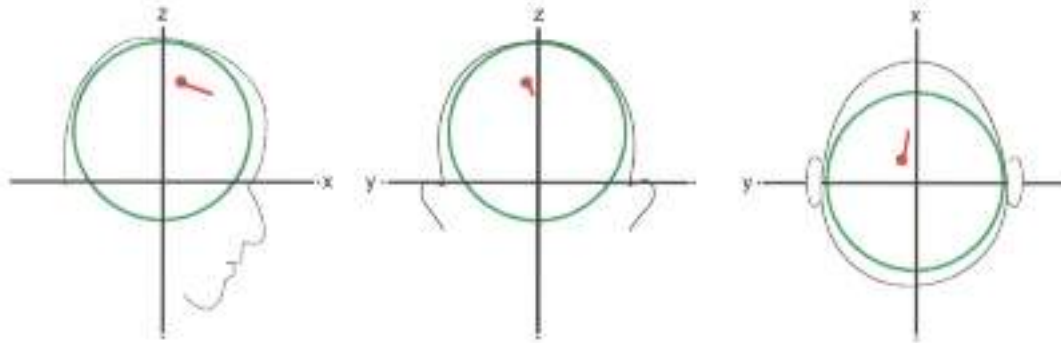
Neurologische Universitätsklinik, Allgemeines Krankenhaus der Stadt Wien, Währinger Gürtel 18–20, A-1090 Wien, Austria

Received January 2, 1991 / Accepted July 26, 1991

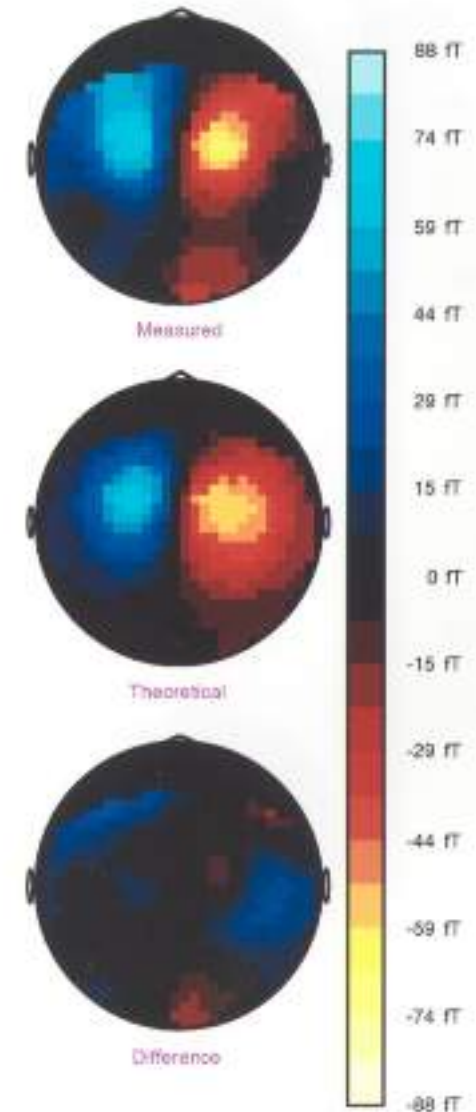
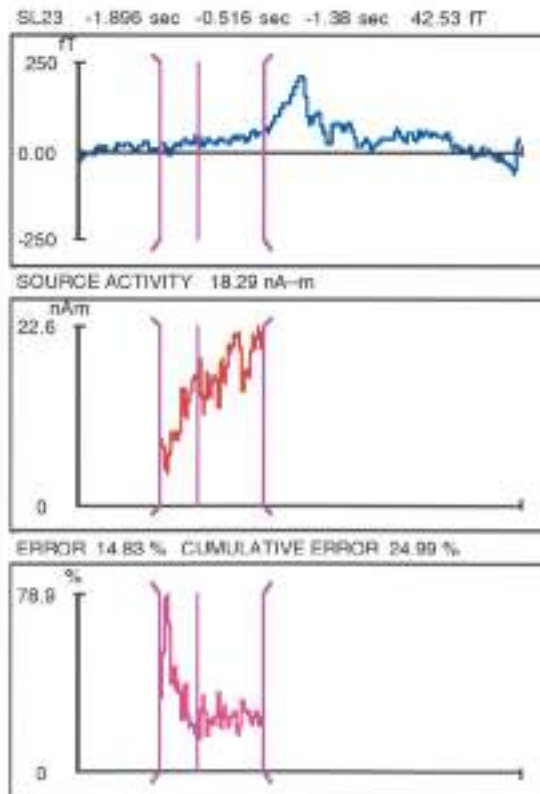
**SMA
Activation
prior to the
movement
and even
prior to the
activity
of the
Primary
Motor
Cortex
in the
MEG.
Patient**

MEG Tapping BF1 - Bereitschaftsfield 1

Map and Dipole Localisation 1.38 sec prior to Tapping Task

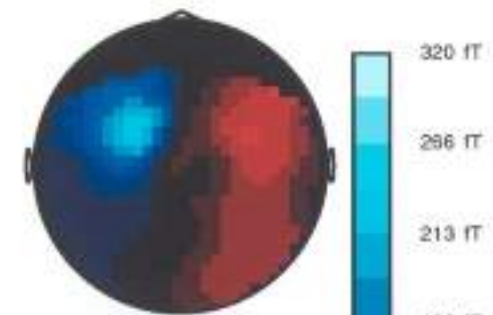
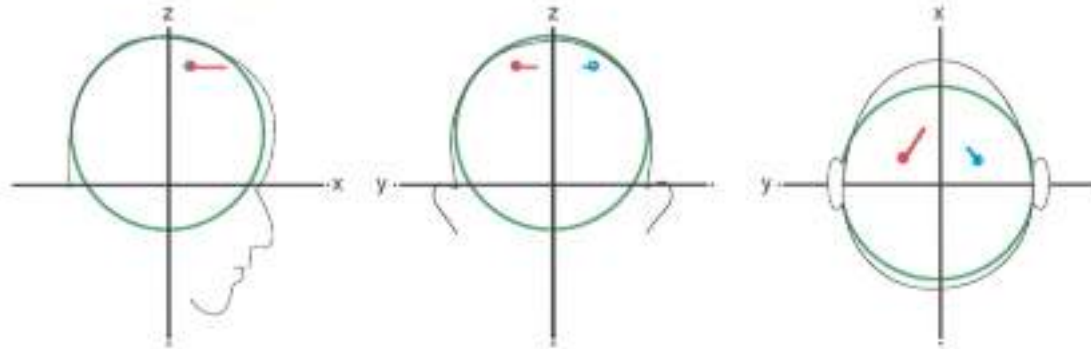


Dipole Fit			
Dipole	x (mm)	y (mm)	z (mm)
t	17.04	9.795	82.28
Dipole	az (deg)	deol (deg)	Q (nAm)
t	349.4	109.5	18.29
Model Sphere			
x (mm)	y (mm)	z (mm)	r (mm)
0	0	40	75
Latency			
Start Latency	-1.896 s		
End Latency	-0.512 s		
Current Latency	-1.38 s		
Cumulative Error: 24.99 %			
Fit Method: Spatio-Temporal			
Magnetic Field Eqn: Grynszpan-Geselowitz			

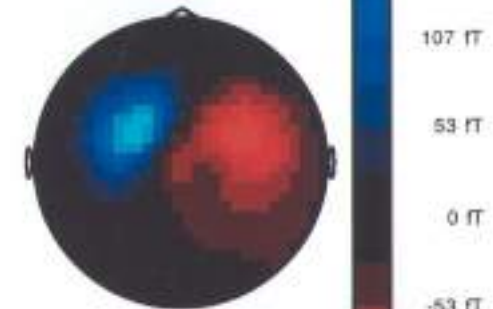


MEG Tapping BF2 - Bereitschaftsfield 2 Lateralized

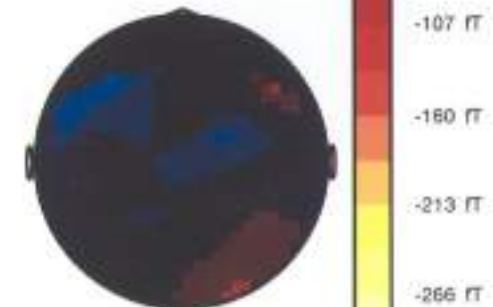
Map and Dipole Localisation 0.024 sec prior to Tapping Task



Measured



Theoretical



Difference

Dipole Fit

Dipole	x (mm)	y (mm)	z (mm)
1	19.62	29.43	94.84
2	17.69	-32.7	94.84

Dipole	az (deg)	decl (deg)	Q (nAm)
1	329.2	0.0	27.27
2	33.69	86.59	12.83

Model Sphere

x (mm)	y (mm)	z (mm)	r (mm)
0	0	40	80

Latency

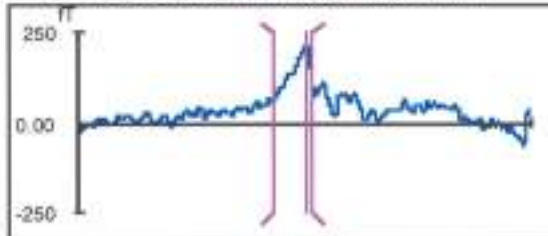
Start Latency -0.424 s
End Latency 0.092 s
Current Latency 0.024 s

Cumulative Error: 19.3 %

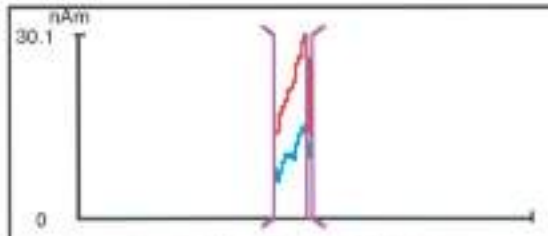
Fit Method: Spatio-Temporal

Magnetic Field Eqn: Grynszpan-Geselowitz

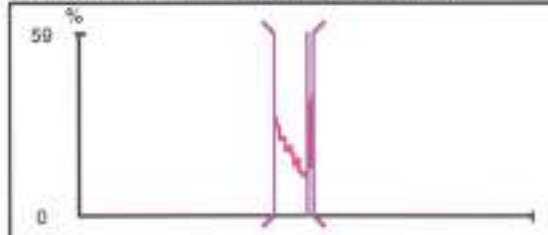
SL23 -0.424 sec 0.086 sec 0.024 sec 212.9 fT



SOURCE ACTIVITY - 27.27 nAm

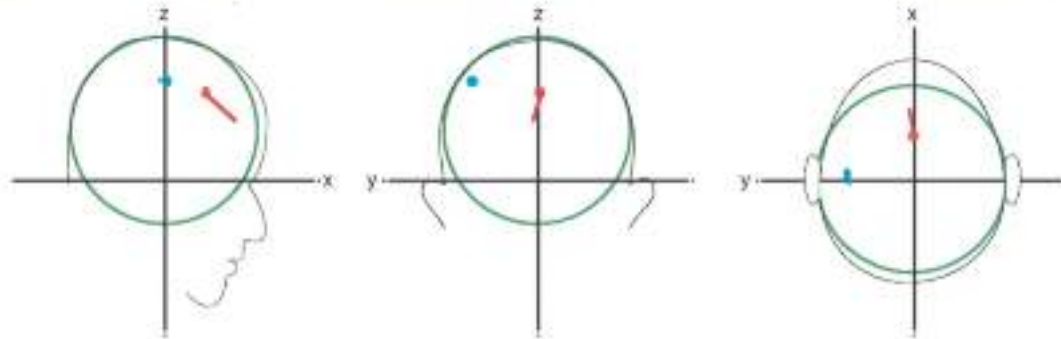


ERROR 14.33 % CUMULATIVE ERROR 19.3 %



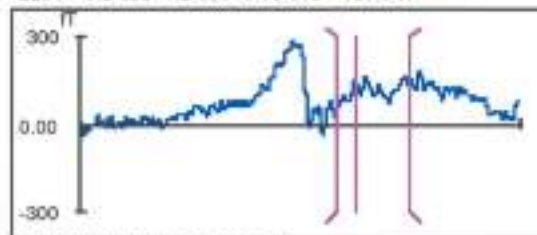
MEG Tapping N-P Negativity of Performance

Map and Dipole Localisation 0.76 sec Following Onset of Tapping Task



Dipole Fit			
Dipole	x (mm)	y (mm)	z (mm)
1	3.607	54.86	62.33
2	35.47	-1.461	73
Dipole	az (deg)	decl (deg)	Q (nAm)
1	188.9	74.09	9.435
2	194.1	44.1	-43.3
Model Sphere			
x (mm)	y (mm)	z (mm)	r (mm)
0	0	40	80
Latency			
Start Latency 0.5 s			
End Latency 1.504 s			
Current Latency 0.76 s			
Cumulative Error: 40.13 %			
Fit Method: Spatio-Temporal			
Magnetic Field Eqn: Grynszpan-Geselowitz			

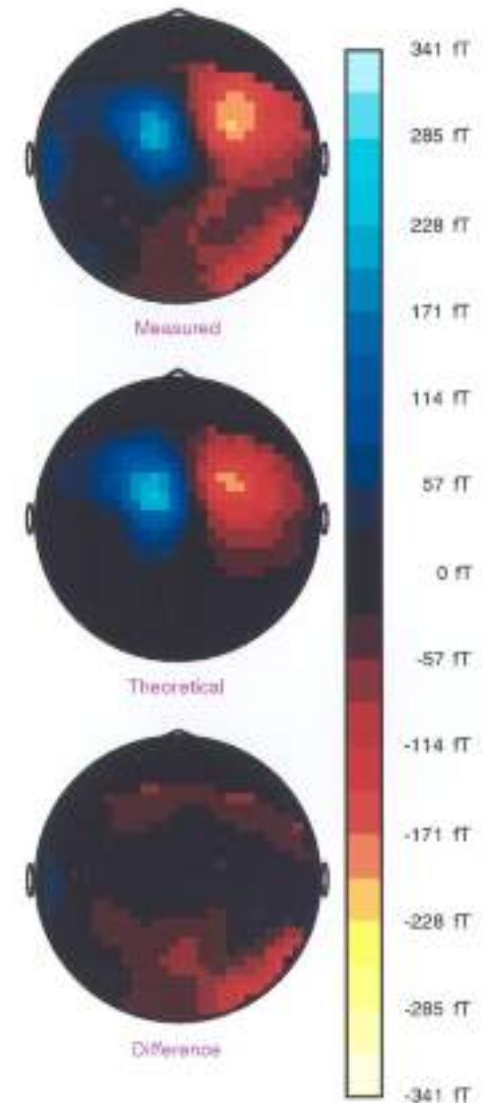
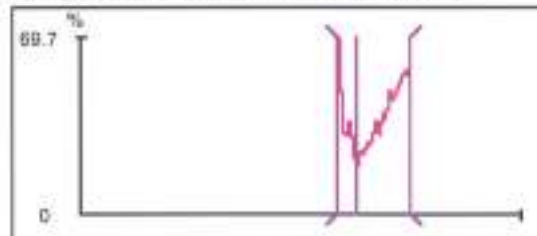
SL34 0.5 sec 1.5 sec 0.76 sec 139.8 fT



SOURCE ACTIVITY 9.435 nA-m



ERROR 18.99 % CUMULATIVE ERROR 40.13 %



Supplementary Motor Area Activation Preceding Voluntary Movement Is Detectable with a Whole-Scalp Magnetoencephalography System

M. Erdler,* R. Beisteiner,* D. Mayer,* T. Kaindl,* V. Edward,* C. Windischberger,†
G. Lindinger,* and L. Deecke*

*Department of Clinical Neurology, General Hospital and University of Vienna and Ludwig Boltzmann Institute for Functional Brain Topography, A-1090 Vienna, Austria; and †NMR-Group-Institute for Medical Physics, University of Vienna, Vienna, Austria

Received September 3, 1999

Despite the fact that the knowledge about the structure and the function of the supplementary motor area (SMA) is steadily increasing, the role of the SMA in the human brain, e.g., the contribution of the SMA to the Bereitschaftspotential, still remains unclear and controversial. The goal of this study was to contribute further to this discussion by taking advantage of the increased spatial information of a whole-scalp magnetoencephalography (MEG) system enabling us to record the magnetic equivalent of the Bereitschaftspotential 1, the Bereitschaftsfeld 1 (BF 1) or readiness field 1. Five subjects performed a complex, and one subject a simple, finger-tapping task. It was possible to record the BF 1 for all subjects. The first appearance of the BF 1 was in the range of -1.9 to -1.7 s prior to movement onset, except for the subject performing the simple task (-1 s). Analysis of the development of the magnetic field distribution and the channel waveforms showed the beginning of the Bereitschaftsfeld 2 (BF 2) or readiness field 2 at about -0.5 s prior to movement onset. In the time range of BF 1, dipole source analysis localized the source in the SMA only, whereas dipole source analysis containing also the time range of BF 2 resulted in dipole models, including dipoles in the primary motor area. In summary, with a whole-head MEG system, it was possible for the first time to detect SMA activity in healthy subjects with MEG. © 2000 Academic Press

Key Words: supplementary motor area; magnetoencephalography; Bereitschaftsfeld; readiness field; motor cortex; voluntary movement.

INTRODUCTION

One of the long-standing questions in motor neuroscience is whether the Bereitschaftspotential (BP) cannot be explained by potentials from both primary motor cortices (M1). Rather, the vertex BP must have its own generator independent of the M1 area, the best candidate being the supplementary motor area (SMA; Deecke and Kornhuber, 1978), which was first described by Vogt and Vogt (1919) in the monkey and by Foerster (1936) in humans.

Subsequently, many authors investigated the structure and the function of the SMA with different methods. SMA activity during voluntary hand movement has been shown using regional cerebral blood flow (rCBF) measurements with the gamma camera (Lassen *et al.*, 1978a, b), and using positron emission tomography (PET) (Roland *et al.*, 1980). Referring to these results, some authors have stated that the SMA functions as a "supramotor area" for programming and execution of voluntary movements (Orgogozo and Larsen, 1979; Roland *et al.*, 1980; Goldberg, 1985). However, in view of electrophysiological recordings, the term "premotor area" appears to be sufficient (Deecke, 1987, 1990). On the basis of movement-related electrical potentials, SMA was proposed as the major source of the BP, as well as the region of the brain where functions such as will or intention to move are represented (Barrett *et al.*, 1986; Kornhuber *et al.*, 1989). The finding that performance of bilateral hand movements is impaired in patients with unilateral SMA lesion, and related work, supported the notion that the SMA functions bilaterally and is involved in organizing the timing and coordination of sequential movement (Dick *et al.*, 1986; Deecke *et al.*, 1987; Deecke, 1990; Lang *et al.*, 1991; Deiber *et al.*, 1991; Grafton *et al.*, 1993).

Discussion has also been centered around the question of whether serial or parallel processing of SMA

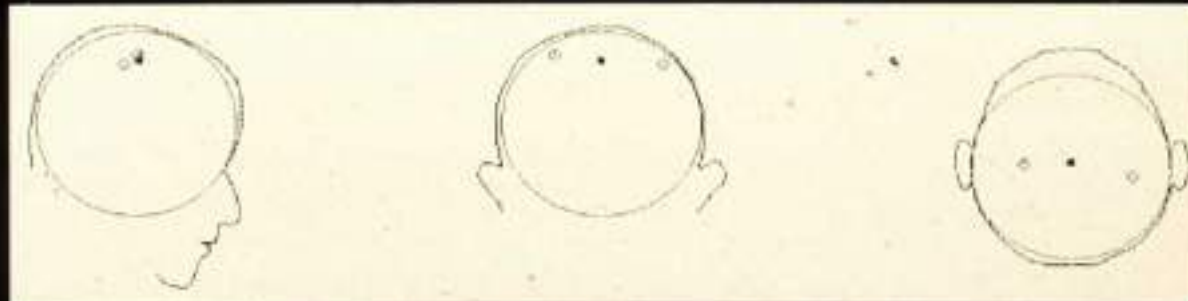
2-dipole & 3-dipole model in the same subject

dipole
moment
contralateral:
2.4 nAm



dipole
moment
ipsilateral:
1.6 nAm

time epoch: -1.7 to 1 s



time epoch: -0.7 to 0 s

**Tapping: The 2 SMAs
- Dipole Moments**

Now
further
refined

!!!



Event-related fMRI of Voluntary Movement: *The Bereitschafts-BOLD Response*

^{1,2}Ross Cunnington, ³Christian Windischberger, ⁴Lüder Deecke, and ³Ewald Moser.

¹Howard Florey Institute and ²Centre for Neuroscience, University of Melbourne, Victoria, Australia.

³Institute for Medical Physics and ⁴Department of Clinical Neurology, University of Vienna, Austria.



Introduction

Activity of motor areas of the cortex begin to increase 1 to 2 s prior to voluntary self-initiated movement, reflecting processes associated with the preparation and readiness for movement. Such activity has been well studied electrophysiologically and termed the *Bereitschaftspotential* or readiness potential. Functional imaging studies (PET and fMRI) have shown the involvement of the supplementary motor area (SMA) and lateral premotor area in processes associated with the preparation and organisation of voluntary movement. These studies, however, have generally lacked the temporal resolution to examine the precise timing of blood oxygen level dependent (BOLD) changes associated with self-initiated voluntary finger movement.

In this study, we used event-related fMRI with a fast repetition rate (250 ms) in order to examine the direct fMRI equivalent of the *Bereitschaftspotential*. We aimed to examine the temporal characteristics of activation (BOLD changes) within supplementary motor and primary motor areas prior to self-initiated voluntary movement.

BP in the basal ganglia

Cunnington et al. 2002

Cunnington R, Windischberger C, Deecke L, Moser E: The preparation and execution of self-initiated and externally-triggered movement: A study of event-related fMRI. Neurolmage 15: 373-385 (2002)

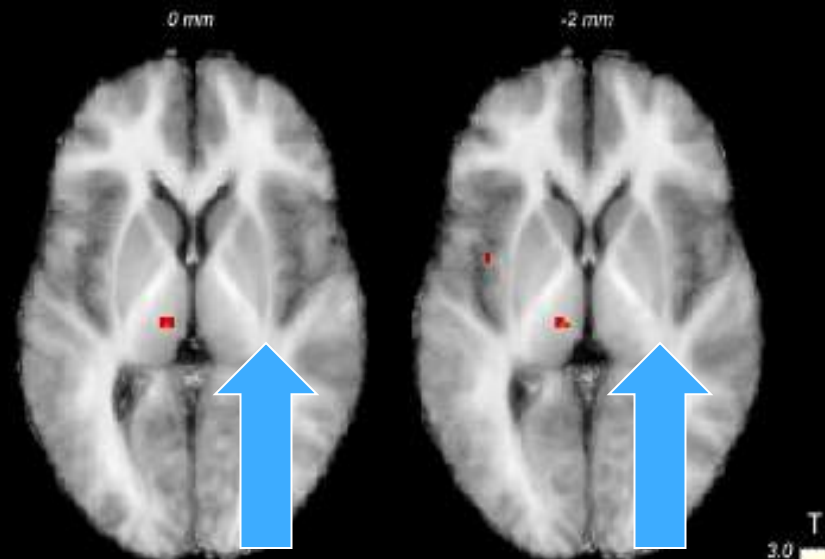
Cunnington R, Windischberger C, Deecke L, Moser E: The use of single event fMRI and fuzzy clustering analysis to examine haemodynamic response time courses in supplementary motor and primary motor cortical areas. Biomed Technik 44 (Suppl 2): 116-119 (1999)

Cunnington R, Windischberger C, Deecke L, Moser E: The preparation and readiness for voluntary movement: a high-field event-related fMRI study of the Bereitschafts-BOLD response. Neurolmage 20: 404-412 (2003)

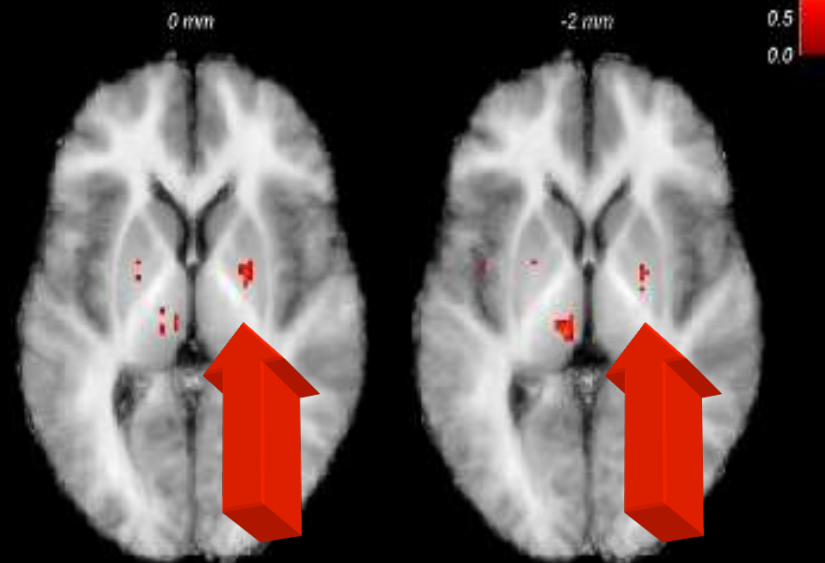
Basal ganglia activation only with self-initiated movements



(a) Externally-Triggered



(b) Self-Initiated





**Other people
meet at Terry
's: Hal,
Gertraud,
Barry**



NSERC

Industrial Synergy Award
given to two eminent scientists:



Hal Weinberg SFU and



Jiří Vrba CTF

in 2005 in Halifax